Proton Form Factor Ratio Measurement with BLAST

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for the BLAST Collaboration

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Introduction:

The electric and magnetic form factors give information about the underlying charge and magnetism structure of the proton.

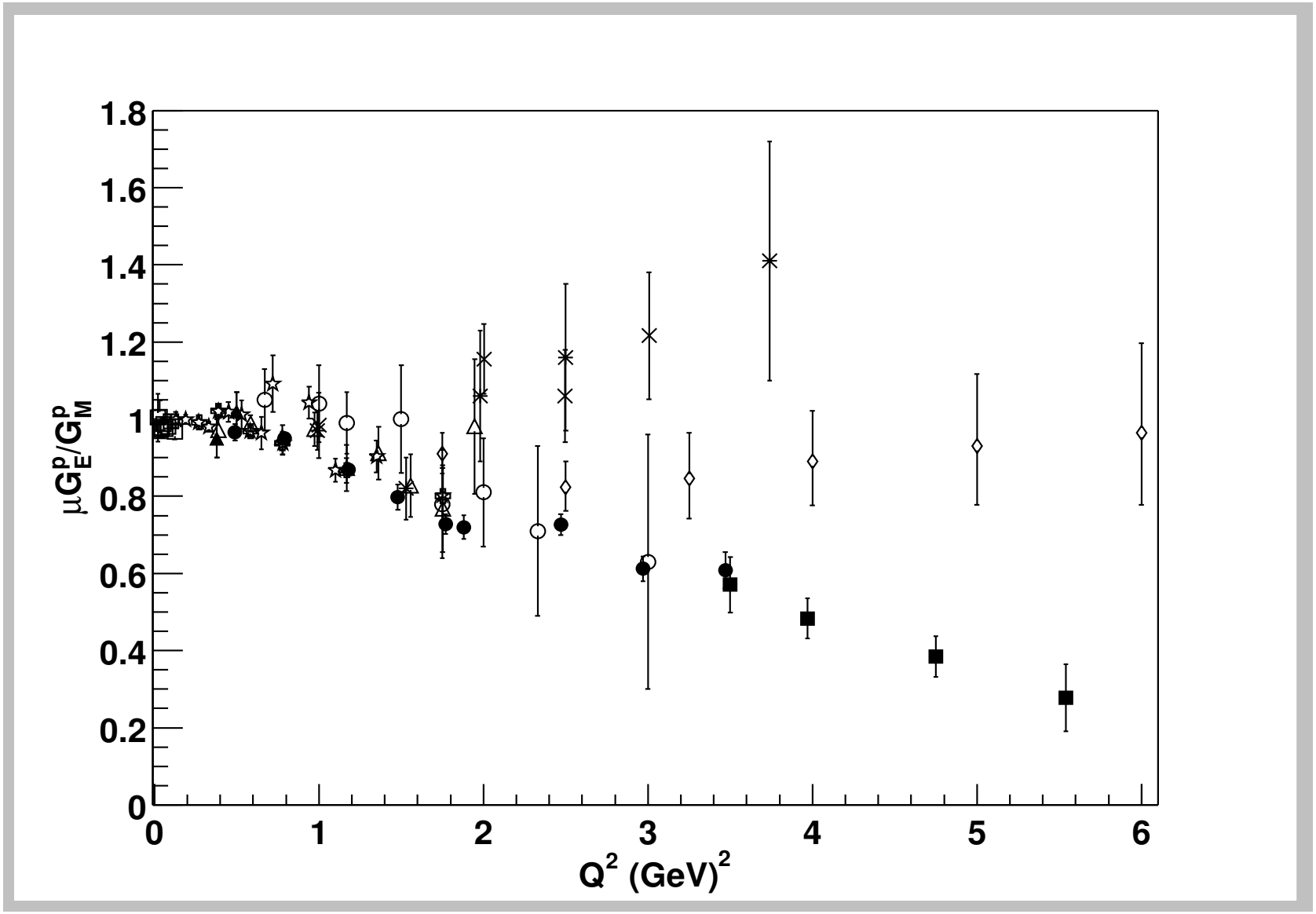
Recent results indicate a striking departure from the standard dipole parameterization for G_E/G_M.

BLAST's symmetric design and large acceptance allows for very small systematic uncertainties.

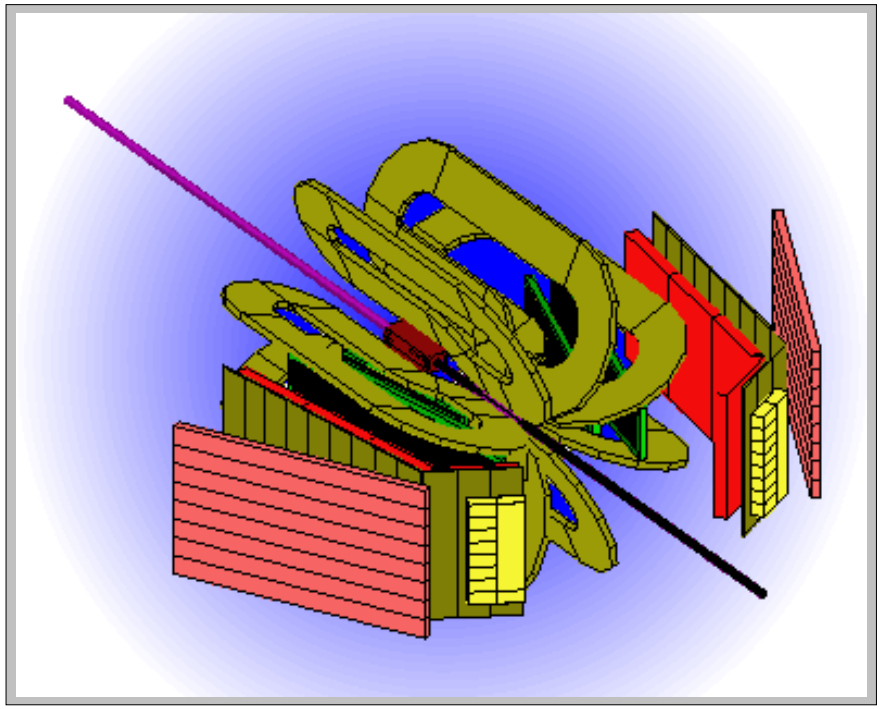
The measurement at BLAST will use a different experimental technique from the JLab experiments and will be subject to different systematic uncertainties.

BLAST will map the proton form factor ratio from 0.08 –1 $(GeV/c)^2$, providing some overlap with the most recent results from JLab.

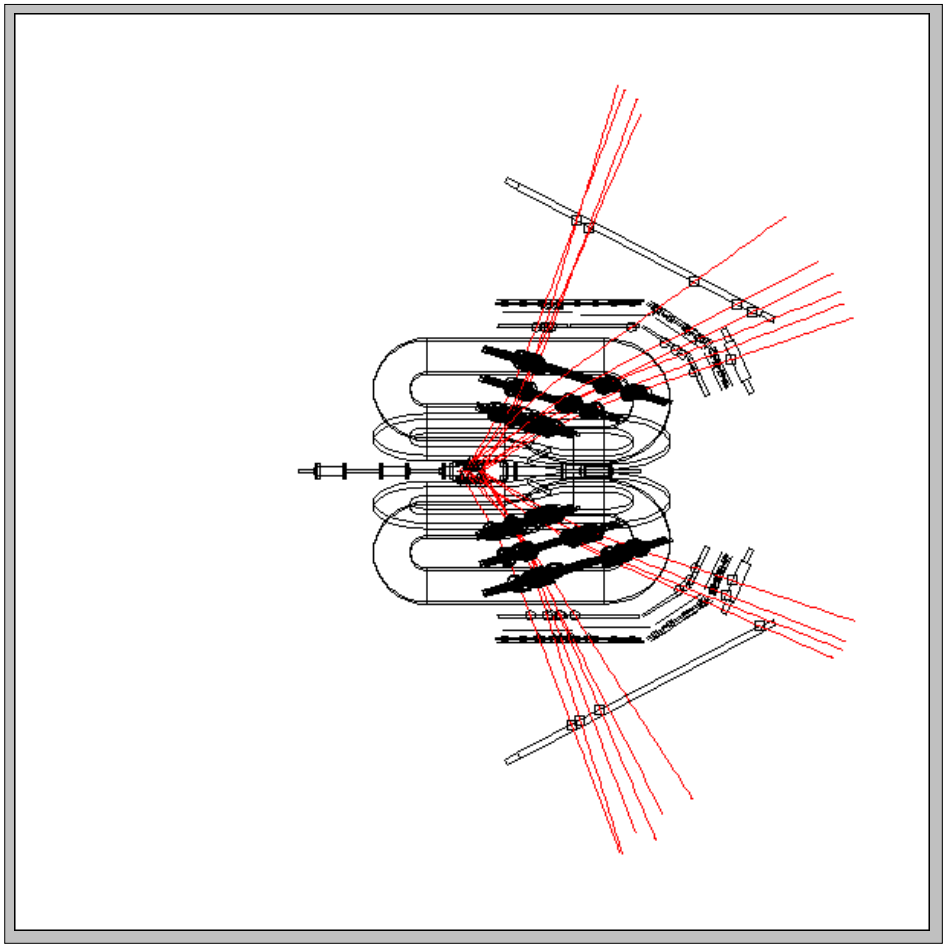
World Form Factor Ratio Data:



BLAST:



Target, Coils, and Detectors



Events in BLAST

Experimental Overview:

Polarized electron beam:

- 80 mA at 440 MeV and 880 MeV
- > 60% polarization

Atomic Beam Source target:

- 80% polarization
- thickness of ~ 10^{14} cm^{-2}
- flow of 3.5×10^{16} atoms/s
- expected luminosity is 2.7×10^{31} cm^{-2}

BLAST detector:

- large symmetric acceptance.
- covers: $20° < \theta < 90°$, $-15° < \varphi < 15°$
- plans to extend coverage to $\theta \sim 113°$

Asymmetries:

The differential ep elastic cross section is:

$$\frac{d\sigma}{d\Omega} = \Sigma + h\Delta$$

The asymmetry is given by:

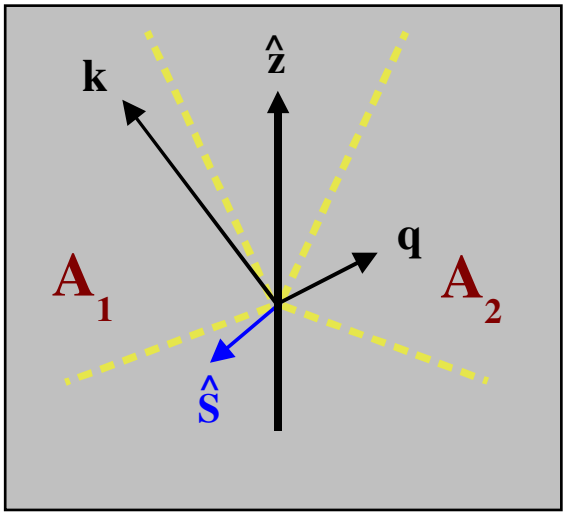
$$A = \frac{\Delta}{\Sigma} = -\frac{2\tau v_{T'} \cos\theta^* G_M^{p\,2} + 2\sqrt{2\tau(1+\tau)} v_{TL'} \sin\theta^* \cos\phi^* G_M^p G_E^p}{(1+\tau) v_L G_E^{p\,2} + 2\tau v_T G_M^{p\,2}}$$

measured asymmetry is

$$A_{meas} = \frac{N_\uparrow - N_\downarrow}{N_\uparrow + N_\downarrow} = P_b P_t A$$

From Asymmetries to the Form Factor Ratio:

The symmetry of BLAST allows us to form two independent asymmetries simultaneously:



We can form a ratio of these two asymmetries to reduce systematic uncertainties:

$$R_A = \frac{A_1}{A_2}$$

Extracting the Form Factor Ratio:

Factoring out $G_M^{p\,2}$ gives:

$$R_A = \frac{2\tau v_{T'} \cos\theta_1^* + 2\sqrt{2\tau(1+\tau)} v_{TL'} \sin\theta_1^* \cos\phi_1^* R}{2\tau v_{T'} \cos\theta_2^* + 2\sqrt{2\tau(1+\tau)} v_{TL'} \sin\theta_2^* \cos\phi_2^* R}$$

Finally, the form factor ratio is:

$$R = \frac{G_E^p}{G_M^p} = \alpha \frac{R_A \cos\theta_2^* - \cos\theta_1^*}{\sin\theta_1^* \cos\phi_1^* - R_A \sin\theta_2^* \cos\phi_2^*}$$

Uncertainties:

$$R = \frac{G_E^p}{G_M^p} = \alpha \frac{R_A \cos\theta_2^* - \cos\theta_1^*}{\sin\theta_1^* \cos\phi_1^* - R_A \sin\theta_2^* \cos\phi_2^*}$$

Statistics:

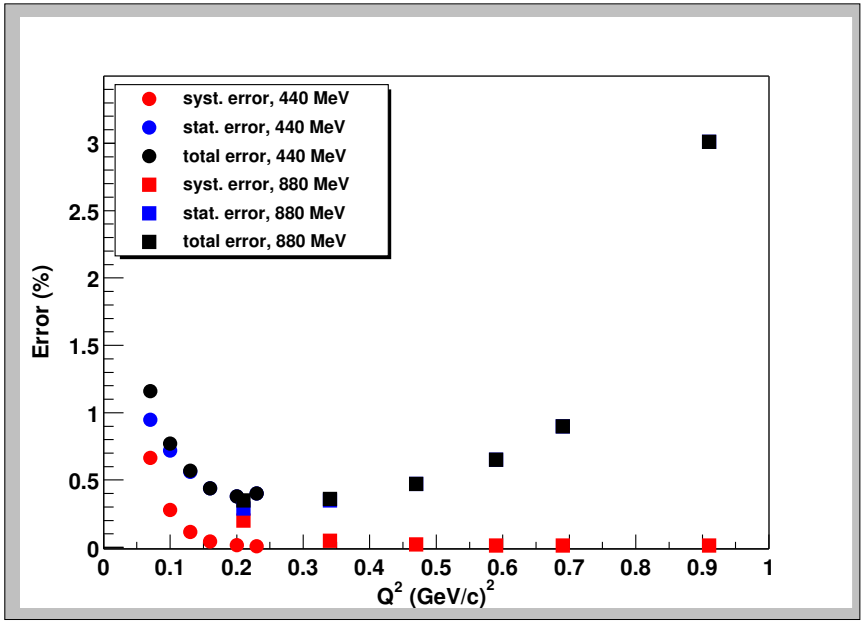
- Uncertainty in R_A

Systematics:

- error in R due to θ_1^*, θ_2^*
- Momentum: $\Delta p/p$ ~ 1%
- Scattering angle: $\Delta\theta$ ~ 1 mrad
- Spin angle: $\Delta\beta$~ 1 mrad

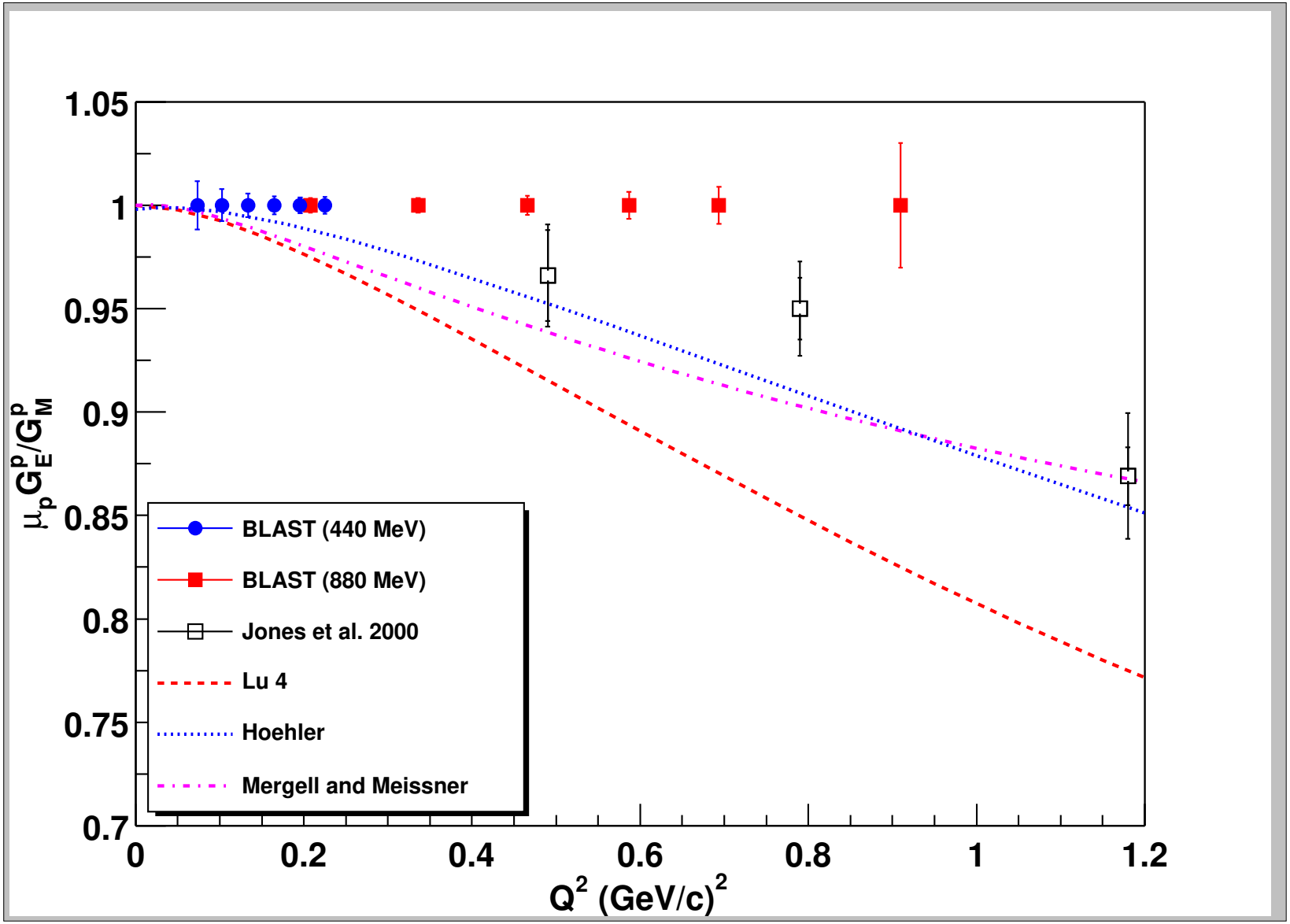
We use an analytic code to model the experiment.

- estimates event rates (stat. error)
- computes derivatives (syst. error)

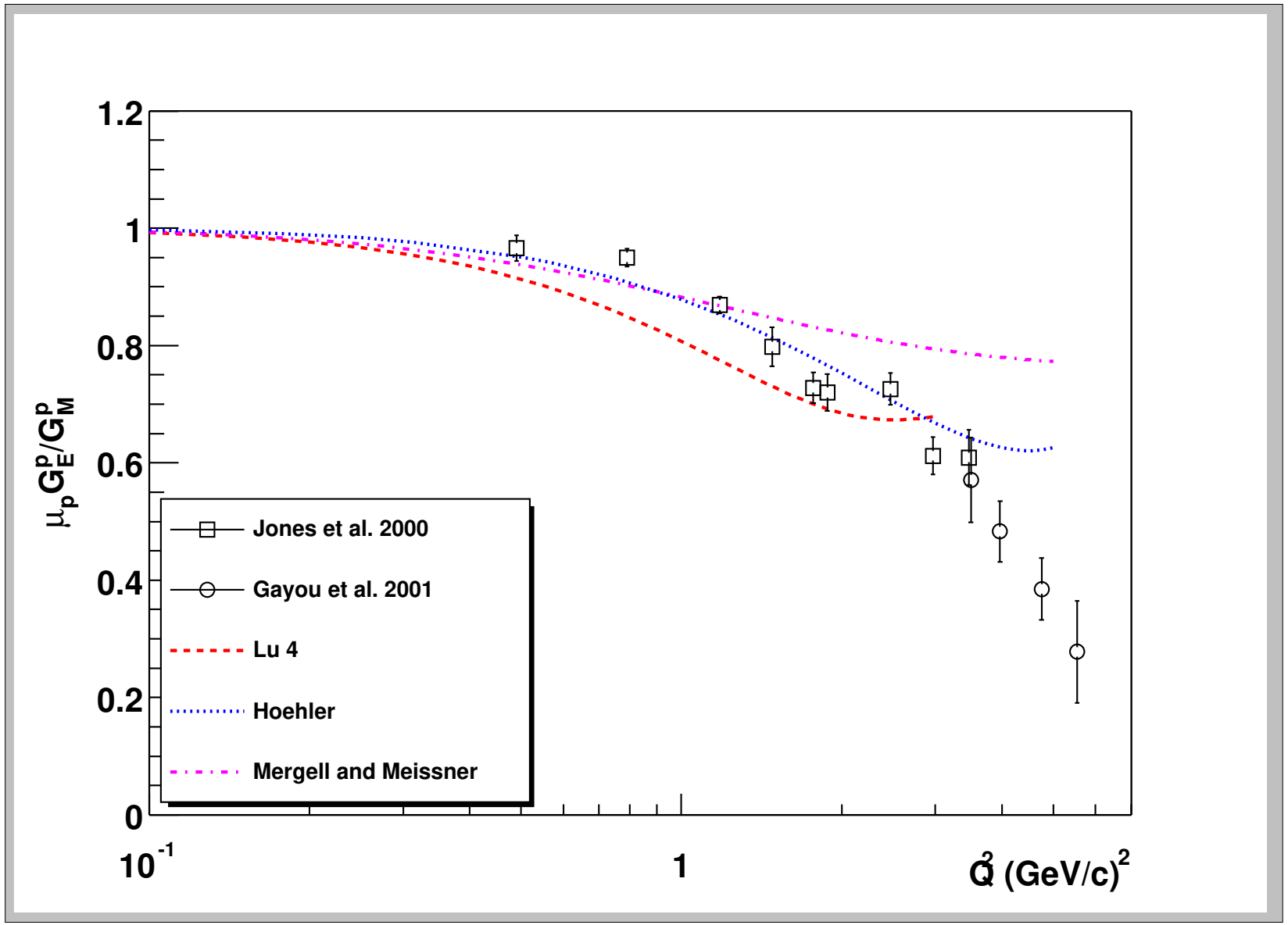


Statistical errors dominate.

Projections:



JLab Results:



Summary:

A measurement of the proton form factor ratio will be carried out with the BLAST detector at Bates.

The polarized beam and target, and BLAST's symmetric design provide a remarkable reduction in systematic uncertainties.

Measurements at beam energies of 440 MeV and 880 MeV will cover the Q^2 range from 0.08 – 1 $(GeV/c)^2$.

The experimental technique will be different than that used in recent JLab experiments, and will provide an important check in the overlapping region.

The high precision of the measurements should provide a distinction among the various theoretical models.